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THE PENNSYLVANIA RAILROAD
For the Information of the Public:

A CENTURY OF RAIL DEVELOPMENT

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After careful consideration, and with the most helpful cooperation on the part of the steel companies, the Pennsylvania Railroad has this year put in service a new standard rail section for heavy duty use, weighing 152 pounds to the yard. The first heats were rolled and placed in the track in May and June, 1931.

Aside from its technical significance, the production of this rail, the heaviest and strongest ever manufactured for regular service on any railroad, constituted an event of much historic interest as it signalized the rounding out of an even century of progress in the evolution of the T-rail. Further interest attaches to the fact that the original T-rail was the invention of a celebrated engineer who designed it for use on what is now a portion of the Pennsylvania Railroad System.

On May 16, 1831, there arrived in Philadelphia, from England, the first T-rails ever produced. They weighed 36 pounds to the yard, were 3½" in height and 3¼" wide at the base. They were rolled of iron, and were for the track of the Camden & South Amboy Railroad, projected to run from Camden, N. J., on the Delaware River, opposite Philadelphia, to South Amboy, N. J., on the Raritan River. This line is in operation today as part of the New York Division of the Pennsylvania Railroad. Its first President and Engineer, Robert L. Stevens, son of Col. John Stevens, the prophetic advocate of railroads vs. canals, designed the rail and invented the principle of the "T"section.

Stevens' achievement proved to be one of the notable mileposts in transportation history. The fundamentals of his design have been retained to the present day, and the "T" section remains the standard type of rail

in nearly every country in the world. Its influence was particularly important in the United States, where a primary requirement for the opening up and development of a new and debtor country was a rail answering fully the needs of service and at the same time capable of being produced and laid at reasonable costs.

From Stevens' T-rail of 1831 to the 152 pound section of 1931 is a far cry, and many steps have intervened. It is necessary, however, to pass them by and proceed to a brief description of the new rail and the circumstances relating to its adoption.

The trend of modern railroading is toward increased capacity and lading for freight cars, increased weight of passenger equipment, increased length of trains in both branches of the service, and steadily advancing speeds. The influence of these factors is likely to grow rather than diminish in the future. Where they are encountered in maximum degree, the result has already been the development of wheel load pressures and the attainment of speeds beyond the durability of the rail heretofore in use to withstand. Indications of the reaching of such condition are given by the life of the rail, the number of failures, and extent of the annual expenditures required to maintain smooth-riding track, as well as evidences of deficiencies in splicing, as the result of insufficient depth of the splicing area, etc.

Such indications have become sufficiently numerous on portions of the railroad carrying the densest traffic to make it apparent that a review of the requirements was necessary in order to arrive at a solution with respect to a rail design which would meet the problems of producing a stronger track with smoother and more comfortable riding qualities, capable of carrying safely increased traffic, with increased wheel load pressures, at increased speeds, and at the same time with more economical maintenance.

Accordingly, committees were formed of representatives of the United

States Steel Corporation, the Bethlehem Steel Corporation, and the Pennsylvania Railroad. These committees made thorough reviews and analyses of the problem, and set for their aim a rail design that would accommodate safely and satisfactorily 100,000 pound axle loads at a speed of 100 miles per hour. These requirements compare with 80,000 pound axle loads at speeds of 80 miles per hour, applicable to the 130-pound main line standard rail section heretofore in use on the Pennsylvania Railroad. It was concluded that this increased allowance for axle loads and speed would take care of the transportation developments of the next twenty-five years.

The chemical composition and desirable arithmetical attributes, as to stiffness and strength, were fixed, and the design made accordingly, in order to fit as nearly to these attributes as possible.

Calculations were made indicating the stresses to be obtained from a purely theoretical standpoint. The result was to demonstrate the necessity for a rail section in which would be incorporated, among others, the following features, namely:

1. A height of approximately 8", or 1-3/8" higher than the 130-pound section heretofore standard, as an important element in increasing the stiffness of the rail.

2. A head designed with as flat a radius as would be practicable to manufacture, in order to give broad contact with the wheel tread.

3. A definite desirable ratio of the perimeter of each portion of the rail -- that is the head, the web and the base -- to their respective volumes, in order that the rate of cooling should be as nearly even as possible to minimize the setting up of internal stresses in the process.

4. That the rail should be canted in the ratio of one to 40, by use of a canted tie plate, as a further means of providing better contact between the head of the rail and the wheel tread.

The working out of these requirements produced a section weighing 152 pounds to the yard, and possessing 75% greater stiffness than the previous 130-pound section.

In determining the surface of the head, in order to have the surface stresses initially as low as possible, the contours of the wheel treads on many cars in active service were studied and an average made. As a result, it was found that a 24" radius for the surface of the rail head would be the nearest fit to the average contour that would be practicable to roll. Observation, so far, of the behavior of this rail in the track has indicated that the contact between the rail and wheel has been materially extended, and the object sought has therefore been attained.

As a result of the knowledge gained in designing the new 152-pound section, the 130-pound section has been revised to accord with the principles of the new design. The result has been to add 22% to the stiffness of the rail, with an increase of only one pound per yard in weight. The new 131-pound section will hereafter be the standard on main line track, except where extraordinary conditions of traffic require the 152-pound section. The latter is now being laid at various points between New York and Pittsburgh, and its use on the main east and west and north and south stems of the system will be progressively extended, to replace existing rail, as conditions of traffic and wear warrant.

The deficiencies in splicing, to which reference has been made, were met by utilizing the greater "fishing" space provided in the higher web of the new rails. This has made it possible to design a simpler but more effective form of splice, which results in a much improved rail joint. In particular, features of design have been introduced which produce greater vertical stiffness, as well as lateral resiliency. The latter makes it possible to take up the wear and tear that occurs between the under side of the head of the rail and the top of the splice.

It may be appropriate to append to this brief description of the new rails, a reference to the fact that the Pennsylvania Railroad was the first

American system to adopt steel rails. The production of steel rails, as is widely known, was made a commercial possibility by the perfecting of the Bessemer process and the great cheapening in the cost of making steel which followed.

In 1862, John Edgar Thomson, then President of the Pennsylvania Railroad, made a study of the production of steel rails in England, where they were being placed on the market for the first time. Impressed with their advantages, he decided to purchase 400 tons for experimental use. They were placed in the track for test purposes between Altoona and Pittsburgh. The weight of these rails was 56 pounds to the yard. The results of the tests were so favorable that the management decided to adopt steel rails as the standard for subsequent purchases.

The 130-pound section, which has just been superseded for standard Pennsylvania Railroad main line use by the new 152-pound and 131-pound sections, was adopted in 1916. It was a modification of and improvement upon a 125-pound section adopted in 1914. Prior to that, the standard main line rail of the Pennsylvania Railroad had been a 100-pound section since the early '90's, and various lighter sections were in use in earlier years.

The Pennsylvania Railroad's average requirements for steel rails are approximately 175,000 tons per year. The actual quantities of new steel rails placed in Pennsylvania Railroad track during the last decade are shown in the following table:

1921	149,765	tons
1922	133,520	"
1923	142,423	"
1924	157,925	"
1925	203,672	"
1926	217,995	"
1927	212,844	"
1928	237,664	"
1929	205,815	"
1930	121,941	"

The story of the designing of the original T-rail is of such interest, and the circumstance itself so important in the evolution of railroads, as to warrant a summary in connection with the fact that 100 years have now passed.

The minutes of the Board of Directors of the Camden & South Amboy Railroad show that in September, 1830, Robert L. Stevens, as President and Engineer of the Company, was instructed to visit England for the purpose of inspecting and reporting upon railroad matters there. In particular he was directed to make purchases of "all iron rail." This, the management of the Company, with unusual foresight, preferred to the wooden rail, plated with strap iron, which was used in the construction of many of the other early American roads. Rails of that type were reasonably satisfactory where horsepower was used, but proved inadequate to the locomotive. This was strikingly demonstrated in the famous trial trip in 1829 of the "Stourbridge Lion" on the tramway of the Delaware & Hudson Canal Company between Carbondale and Honesdale, Pa. The trip, which was the first movement of a steam locomotive on an American railway, was a complete success as far as the engine was concerned, but a failure on the part of the track.

Upon receiving his instructions from the Camden & South Amboy Board, Stevens sailed for England a few days later. During the voyage he employed his time by whittling out model sections of rail from wood obtained from the ship's carpenter.

The best railways of England at that time were being laid with what was known as the Birkenshaw rail, sometimes, from its shape, called the "fish belly." It had a head not unlike that of the T-rail, and a high web, but no base. It was notable as being the first iron rail ever produced by rolling. The only other all-iron rails previously in use had been of cast metal and in lengths of not over 3½ feet.

Birkenshaw rail gave good results as far as operation was concerned, but was expensive to lay, by reason of the fact that its construction required that the baseless web rest in cast iron "chairs" which were spiked to stone blocks at intervals of three feet. Stevens perceived that this rail was not adapted to conditions in new America where metal workers were scarce and iron dear. He therefore conceived the idea of adding the continuous flat base, which dispensed with the necessity for chairs.

Stevens never patented his rail invention, which, by reason of its almost universal use, might have made him enormously rich. He frequently expressed regret in after life that he had not done so, and on one occasion investigated the possibility of obtaining a patent, but found that too long a period had elapsed, and that his invention had become public property.

For use with the T-rail, Stevens also designed the "hook-headed" spike, which is substantially the railroad spike of today. The spikes were driven into wooden plugs inserted into the stone blocks before the latter were superseded by wooden ties. To join the rail lengths together he devised what was called the "iron tongue," which later evolved into the fish plate and subsequently into the modern joint-bar. In the rail joint, as planned by Stevens, rivets were used, which have long since been replaced by the bolt and nut to complete the joint.

Upon arrival in London, Stevens addressed a letter to the iron-masters of Great Britain requesting bids. It was accompanied with a cross-section, side elevation and ground plan. The letter read:

"Liverpool, November 26, 1830.

"Gentlemen: At what rate will you contract to deliver at Liverpool, say from 500 to 600 tons of railway, of the best quality iron rolled to the above pattern in 12 or 16 feet lengths, to lap as shown in the drawing, with one hole at each end, and the projections on the lower flange at every 2 feet, cash on delivery?

"How soon could you make the first delivery, and at what rate per month until the whole is complete? Should the terms

suit and the work give satisfaction a more extended order is likely to follow, as this is but about one-sixth part of the quantity required. Please to address your answer (as soon as convenient) to the care of Francis B. Ogden, consul of the United States at Liverpool.

"I am, your obedient servant,

"Robert L. Stevens,
"President and Engineer of the Camden and South Amboy Railroad and Transportation Company."

It is recorded that Stevens encountered great difficulties in inducing a British mill to attempt making rails of his design, and at first received no favorable replies to his proposals. The ironmasters of the Kingdom for various reasons regarded his undertaking, to quote a commentator, "as dangerous, or at least highly imprudent, and likely to prove disastrous to all concerned." He was, however, fortunate in being personally acquainted with John Guest (afterwards Sir John Guest), a member of Parliament and head of the firm of Guest, Lewis & Co., owners of the Dowlais Works in Wales.

Through this avenue of approach, Stevens prevailed upon Guest to have the rails rolled at his plant. He accompanied Stevens to the works, where the latter gave his personal supervision to the construction of the required rolls. After their completion, the firm gravely hesitated to use them for fear of damage to the mill. Upon learning of this, Stevens deposited a liberal sum to guarantee the cost of the repairs, if any should be required. The receipt for this deposit was long preserved among the archives of the Camden & South Amboy Company. In point of fact, the rolling apparatus did break down several times.

A nephew, Francis B. Stevens, writing in 1881 to the late J. M. Swank, the noted authority on iron and steel, stated that the first experimental rails came from the rolls "curled like snakes, and distorted in every imaginable way." At last, however, the mill men acquired the art of straightening the rail while it cooled.

The first shipment, to which reference has been made, and which reached Philadelphia May 16, 1831, consisted of 550 bars, each 18 feet in length, and, as previously stated, weighing 36 pounds to the yard. In the case of the second shipment, which arrived several months later, the weight was increased to 42 pounds to the yard. Over thirty miles of these rails were immediately laid on the line of the Camden & South Amboy, constituting the forerunner of modern railroad track construction not only for the United States but for the world at large.

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